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Chemical composition, antioxidant and antimicrobial activities of essential oil from the aerial parts of *Chuquiraga arcuata* Harling grown in the highlands of Ecuador

[Composición química, actividades antioxidantes y antimicrobianas del aceite esencial de las partes aéreas de *Chuquiraga arcuata* Harling cultivado en las tierras altas del Ecuador]

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Abstract: The chemical composition, antioxidant and antimicrobial activities of the essential oil from aerial parts (leaves and flowers) of *Chuquiraga arcuata* Harling grown in the Ecuadorian Andes were studied. One hundred and twenty-six compounds were identified in the essential oil. Monoterpene hydrocarbons (45.8%) and oxygenated monoterpenes (44.1%) had the major percentages. The most abundant compounds were camphor (21.6%), myrcene (19.5%), and 1,8-cineole (13.4%). Antioxidant activity was examined using DPPH, ABTS, and FRAP assays. The essential oil had a moderate scavenging effect and reduction of ferric ion capacity through FRAP assay. Antimicrobial activity of the essential oil was observed against four pathogenic bacteria and a fungus. The essential oil exhibited activity against all microorganism strains under test, particularly against *Candida albicans* and *Staphylococcus aureus* with MICs of 2.43-12.10 µg/mL.

Keywords: *Chuquiraga arcuata*; Essential oil; Chemical composition; Antioxidant activity; Antimicrobial activity.

Resumen: Se estudió la composición química, actividades antioxidantes y antimicrobianas del aceite esencial procedente de las partes aérea (hojas y flores) de *Chuquiraga arcuata* Harling cultivadas en los Andes ecuatorianos. Se identificaron 126 compuestos en el aceite esencial. Los hidrocarburos monoterpénicos (45,8%) y los monoterpenos oxigenados (44,1%) tuvieron el mayor porcentaje. Los compuestos más abundantes fueron alcanfor (21,6%), mirceno (19,5%) y 1,8-cineol (13,4%). La actividad antioxidante se examinó mediante ensayos DPPH, ABTS y FRAP. El aceite esencial tuvo un efecto eliminador moderado y una reducción de la capacidad de iones férricos mediante el ensayo FRAP. Se observó actividad antimicrobiana del aceite esencial contra cuatro bacterias y un hongo patógenos. El aceite esencial mostró actividad contra todas las cepas de microorganismos bajo prueba, particularmente contra *Candida albicans* y *Staphylococcus aureus* con CMI de 2,43-12,10 µg/mL.

Palabras clave: *Chuquiraga arcuata*; Aceite esencial; Composición química; Actividad antioxidante; Actividad antimicrobiana.

INTRODUCTION

Chuquiraga Juss. belongs to the Asteraceae family and consists of 27 species and/or subspecies of evergreen shrubs that grow in the Andes and Patagonia (Padin *et al*., 2015). It is the most variable genus morphologically of the subfamily Barnadesioideae, due to the various sizes and colors in their inflorescences, but mainly because of its great diversity of leaf shapes (de Lima-Ferreira *et al*., 2021). Many of these plants are used by the indigenous populations because of their medicinal properties (Casado *et al*., 2011; Arroyo-Acevedo *et al*., 2017, Arroyo-Acevedo *et al*., 2018; Ccana-Ccapatinta *et al*., 2018). Some of them are commercialized in European countries (de Lima-Ferreira *et al*., 2021).

In Ecuador, only two *Chuquiraga* spp. are present at altitudes higher than 3000 meters above sea level in the Andean region: *Chuquiraga jussieui* J. Gmelin and *Chuquiraga arcuata* Harling (de la Torre, 2008). The chemical composition and the biological activities of the essential oil from the endemic species *Chuquiraga* arcuata, popularly named as 'chuquiragua', have not yet been reported.

In the course of our studies on the aromatic plants from the highland region of Ecuador, we report the chemical composition, antioxidant and antimicrobial activities of the essential oil from aerial parts (leaves and flowers) of *Chuquiraga arcuata* Harling.

MATERIALS AND METHODS

Plant material and essential oil isolation

Leaves and flowers of wild plants were collected at 3000 m above sea level in Cañar canton (2°29′1.32″ S, 78°58′42.24″ W), Ecuador during March 2019. The species was identified and a specimen was kept in the herbarium of the Pontificia Universidad Católica del Ecuador (accession number 1971). The essential oil was obtained from three samples (200 g) of fresh material by hydrodistillation in a Clevenger-type apparatus for 3 hours. The essential oil was dried over anhydrous sodium sulfate and stored at 4°C until analysis.

GC-FID and GC-MS analysis

GC-FID was conducted on a Hewlett-Packard 6890N series II (Agilent, Santa Clara, CA, USA) equipped with a DB-5ms column (30 m x 0.25 mm i.d. x 0.25 μm film thickness, J & W Scientific, Folsom, CA, USA). The following conditions were used for analysis: oven temperature was programmed from 70°C (after 2 min) to 250°C at 4°C/min and held for 10 minutes; injector and FID temperatures were set at 250°C. Carrier gas He at a flow rate of 1 mL/min. Diluted sample (10% in diethyl ether, v/v) of 1 μL was injected in split mode (1:20). Quantification of compounds was carried out using relative percentage abundance and normalization method with correction response factors based on grouping the essential oil components by their functional groups (Costa *et al.*, 2008). Percentage data were the mean values of two injections per sample.

GC-MS analysis was performed on a QP-2010 Ultra (Shimadzu, Japan) equipped with a DB-5ms (30 m × 0.25 mm i.d. × 0.25 μm film thickness, J & W Scientific, Folsom, CA, USA) and DB-Wax (30 m × 0.25 mm × 0.25 μm; J & W Scientific, Folsom, CA, USA) capillary columns. The temperature program, carrier flow rate and injection mode were the same as in GC-FID. Electron ionization system with ionization energy of 70 eV was used; mass range: 35-400 m/z. Injector and MS transfer line temperatures were set at 250°C. Identification of the constituents was conducted by comparing the linear retention index (LRI) determined with reference to homologous series of n-alkanes (C_8-C_{24}) and mass spectra with those of commercial libraries (NIST 05, Wiley 6, Adams 2007, and NBS 75 k) and with in-house Flavorlib library. LRIs were also compared against those found in literature and NIST Standard Reference Database (https://webbook.nist.gov/chemistry). In many cases, the essential oil was subject to co-chromatography with authentic compounds.

2,2-Diphenyl-2-picrylhydrazyl (DPPH) assay

The antioxidant capacity was determined in terms of hydrogen donating or radical scavenging ability, using the stable radical DPPH (Tabart *et al*., 2008). In the test tubes, 1.5 mL of DPPH* (0.075 mg/mL) in ethanol were mixed with 750 μL of five concentrations of the essential oil to evaluate in a range of concentrations between 0.2-10 mg/mL A control sample (absolute ethanol) and a reference sample (750 μL absolute ethanol and 1.5 mg/mL of DPPH solution) were also used. The decrease in absorbance was determined at 515 nm, and Trolox was used as antioxidant standard. The IC_{50} values (total antioxidant compound necessary to decrease the initial DPPH radical concentration by 50%) were determined. Analyses were performed by triplicate.

2,2'-Azino-bis(3-ethylbenzothiazoline-6-sulfonic acid (ABTS) assay

The antioxidant capacity was determined in terms of

hydrogen donating or radical scavenging ability, using the stable ABTS*+ radical (Re *et al*., 1999). It was carried out according to the procedure described by Kuskoski *et al*. (2004). The ABTS*+ radical was formed after the reaction of ABTS (7 mM) with potassium persulfate (2.45 mM, final concentration) incubated at room temperature and in the dark for 16 h. Once the ABTS*+ radical was formed, it was diluted with methanol until obtaining an absorbance value of 0.700 at 750 nm. A 100 µL aliquot of the essential oil was added to 1 mL of ABTS*+ solution. The absorbance, after 10 min, was measured spectrophotometrically at 750 nm. The reference synthetic antioxidant Trolox at a concentration of 50 a 700 µmol/L in methanol was tested under the same conditions and the results were expressed in IC_{50} values. Analyses were performed by triplicate.

Ferric-reducing antioxidant power (FRAP) assay

The total antioxidant potential of the sample was measured using the FRAP assay (Benzie & Strain, 1996). The FRAP reagent was prepared by mixing solutions of 10 mM TPTZ (2,4,6-tripyridyl-s-triazine; Sigma) in 40 mM HCl and 20 mM ferric chloride in the ratio 10:1:1. The essential oil (20 µL) was mixed with 900 µL of freshly prepared FRAP reagent. A solution of ascorbic acid was used as standard and Trolox was used as positive control. The mixtures were incubated at room temperature for 4 min and the absorbance was taken at 593 nm. The FRAP was expressed in units of ascorbic acid equivalent. All determinations were carried out in triplicate.

Antimicrobial assays

The antibacterial activity was assayed against some human pathogenic strains from the American Type Culture Collection, Maryland, USA: *Staphylococcus aureus* (ATCC25923), *Escherichia coli* (ATCC 25922), *Salmonella enterica* serovar (ATCC14028) and *Pseudomonas aeruginosa* (ATCC 27853), while the antifungal activity was assayed against the pathogenic fungus *Candida albicans* (ATCC 14053). Strains were kept on Nutrient Agar and Sabouraud slants at 4ºC, for bacteria and fungus respectively. Bacterial strains were activated in Nutrient Agar at 37°C for 24 hours, while the fungus was activated in Sabouraud at 28ºC for 48 hours before testing. The in vitro antimicrobial activity of the essential oil was tested by the agar disc-diffusion assay and the determination of minimum inhibitory concentrations (MIC) as per CLSI guidelines, for the sensible microbial strains (Wikler *et al*., 2006). Aliquots of 10 µL of the essential oil solutions in 5% DMSO at 1, 3, 6, 12 and 24 mg/mL were tested. Ciprofloxacin (30 µg) was used as bacterial positive control and Ketoconazole (33 µg) discs were used for fungus. Activity was measured in terms of zone of inhibition (ZOI). The net zone of inhibition was determined by subtracting the disc diameter (6 mm) from the total zone of inhibition revealed by the test disc in terms of clear zone around the disc. The MIC of the essential oil was determined by micro dilution broth assay using 96 'U' bottom micro-titer plates. All experiments were performed by triplicate.

RESULTS AND DISCUSSION

To date, no chemical investigation has been previously carried out on the essential oil of *Chuquiraga arcuata*. Figure No. 1 shows the gas chromatogram on DB-5ms column of the essential oil. The identified compounds are listed in Table No. 1 in elution order from the DB-5ms column, along with the percentage composition of each component and its retention index. One hundred and twenty-six compounds were identified by GC-MS, comprising 99% of the whole essential oil. The main fractions were constituted by monoterpene hydrocarbons (45.8%) and oxygenated monoterpenes (44.1%) for all the chemical groups. The most abundant compounds were camphor (21.6%), myrcene (19.5%), and 1,8-cineole (13.4%).

According to our knowledge, there are only one report on the composition of *Chuquiraga* spp. essential oils. Apiol, p-methoxyacetophenone and p-hydroxyacetophenone were found as major compounds in *Chuquiraga spinosa* (R. et P.) D. Don (Senatore, 1996).

Antioxidant properties of the essential oil were determined, for the first time for the specie, by three *in vitro* methods: DPPH, ABTS, and FRAP assays (Table No. 2). The result shows that the essential oil scavenged DPPH· radical and ABTS·+ radical capacity as reflected by the IC_{50} values 9.8 ± 0.24 mg/mL and 34.5 ± 0.27 mg/mL, respectively. According to the result the essential oil had reducing radical power in a concentration dependent manner and the FRAP assay, expressed as µM of ascorbic acid equivalents (AAE) was found to be 156.89 ± 0.01 µM of AAE at highest concentration tested. The essential oil of *Chuquiraga arcuata* at 0.5 mg/mL concentration was found to be less potent than Trolox used as reference. Although the scavenging activity against ABTS radicals and FRAP capacity was lower in *Chuquiraga arcuata* essential oil compared to the reference compound, it is worth mentioning that Trolox is considered a potent antioxidant.

Table No. 1
Composition of the essential oil from *Chuquiraga arcuata*

No.	Compound	RI_A[a]	RI_A[ob]	RI_P	RI_P[o]	%[c]
1	2-Methylbutyl acetate	880	884	1111	1115	tr[d]
2	Santolina triene*	910	909	1009	1011	tr
3	α-Thujene	933	930	1012	1019	1.6 ± 0.1
4	α-Pinene	941	939	1029	1026	3.8 ± 0.3
5	Camphene	953	954	1060	1063	5.0 ± 0.4
6	Thuja-2,4(10)-diene*	961	960	1109	1113	5.0 ± 0.4
7	Benzaldehyde	963	960	1510	1509	tr
8	Sabinene	972	975	1118	1115	0.2 ± 0.0
9	1-Octen-3-ol	976	976	1455	1458	tr
10	β-Pinene	978	979	1121	1125	4.4 ± 0.3
11	Octan-3-one	980	984	1266	1270	0.1 ± 0.0
12	Myrcene	986	989	1165	1160	19.5 ± 1.8
13	Octan-3-ol	992	991	1395	1394	tr
14	2,3-Dehydro-1,8-cineole*	994	993	1193	1190	tr
15	*m*-Mentha-1(7),8-diene*	999	1001	-	-	tr
16	(*E*)-3-Hexenyl acetate	1001	1002	1020	1018	tr
17	α-Phellandrene	1002	1003	1179	1177	0.2 ± 0.0
18	α-Terpinene	1014	1017	1190	1189	0.7 ± 0.0
19	*p*-Cymene	1022	1025	1262	1265	0.7 ± 0.0
20	Limonene	1028	1029	1198	1195	3.2 ± 0.1
21	β-Phellandrene	1031	1030	1201	1200	tr
22	1,8-Cineole	1033	1031	1212	1212	13.4 ± 1.3
23	(*E*)-β-Ocimene	1046	1050	1248	1250	0.1 ± 0.0
24	γ-Terpinene	1058	1060	1257	1254	1.4 ± 0.1
25	*cis*-Sabinene hydrate	1069	1070	1468	1467	0.3 ± 0.0
26	Terpinolene	1087	1089	1270	1271	0.7 ± 0.0
27	*p*-Cymenene	1090	1091	1436	1438	0.6 ± 0.0
28	Linalool	1096	1097	1555	1557	0.9 ± 0.1
29	*trans*-Sabinene hydrate	1099	1098	1402	1400	0.2 ± 0.0
30	Nonanal	1102	1101	1397	1400	tr
31	*endo*-Fenchol	1116	1117	1577	1574	tr
32	Chrysanthenone	1126	1128	1500	1504	tr
33	*trans*-*p*-2-Menthen-1-ol*	1138	1141	1551	1553	tr
34	Geijerene*	1140	1143	1334	1338	tr
35	Ipsdienol*	1144	1145	1586	1584	tr
36	Camphor	1146	1146	1500	1497	21.6 ± 2.3
37	Camphene hydrate*	1149	1150	1514	1519	tr
38	Isopulegol	1151	1150	1567	1566	0.1 ± 0.0
39	*trans*-Pinocamphone*	1162	1163	1579	1576	0.1 ± 0.0
40	Pinocarvone	1164	1165	1578	1575	0.1 ± 0.0
41	δ-Terpineol	1168	1166	1683	1680	0.1 ± 0.0
42	Borneol	1170	1169	1703	1700	1.2 ± 0.1
43	*cis*-Pinocamphone*	1172	1175	1534	1530	0.5 ± 0.0
44	Terpinen-4-ol	1175	1177	1601	1606	0.9 ± 0.0
45	*p*-Cymen-8-ol	1180	1183	1854	1850	tr
46	Decan-2-one	1190	1192	1497	1495	0.1 ± 0.0
47	Methyl salicylate	1193	1192	1752	1755	tr
48	Myrtenol	1199	1196	1790	1792	1.1 ± 0.1

49	Verbenone	1204	1205	1712	1710	0.2 ± 0.0
50	*trans*-Piperitol	1207	1208	1744	1745	tr
51	β-Citronellol	1222	1226	1752	1750	0.1 ± 0.0
52	2-Nonyl acetate	1238	1236	1466	1466	tr
53	Pulegone	1237	1237	1641	1644	0.1 ± 0.0
54	Carvone	1246	1243	1727	1725	tr
55	Geraniol	1255	1253	1860	1860	tr
56	Piperitone	1257	1253	1707	1710	0.1 ± 0.0
57	Methyl citronellate*	1260	1261	1599	1596	0.1 ± 0.0
58	Geranial	1268	1267	1730	1733	tr
59	Perillaldehyde	1273	1272	1814	1817	tr
60	Thymol	1290	1290	2149	2153	tr
61	Bornyl acetate	1284	1287	1576	1579	3.0 ± 0.2
62	Undecan-2-one	1292	1294	1598	1595	2.1 ± 0.1
63	Carvacrol	1296	1299	2219	2222	tr
64	Nonyl acetate	1313	1312	1583	1581	tr
65	Methyl geranate	1322	1325	1675	1678	tr
66	Myrtenyl acetate*	1329	1327	1705	1701	tr
67	δ-Elemene	1334	1338	1465	1460	tr
68	Neric acid*	1340	1340	2365	2366	tr
69	α-Cubebene	1349	1351	1467	1468	tr
70	Citronellyl acetate	1355	1353	1666	1663	tr
71	Neryl acetate	1366	1362	1723	1725	tr
72	Carvacryl acetate	1370	1373	1886	1880	0.1 ± 0.0
73	α-Ylangene	1373	1375	1466	1470	tr
74	α-Copaene	1376	1377	1486	1492	0.1 ± 0.0
75	β-Bourbonene	1384	1388	1501	1504	tr
76	β-Cubebene	1388	1388	1540	1542	tr
77	β-Elemene	1391	1391	1593	1590	tr
78	(*E*)-Jasmone	1393	1391	-	-	0.1 ± 0.0
79	Dodecan-2-one	1399	1396	1699	1704	tr
80	Methyl eugenol	1401	1406	2033	2031	0.1 ± 0.0
81	α-Gurjunene	1408	1410	1525	1527	0.1 ± 0.0
82	(*E*)-Caryophyllene	1421	1419	1596	1598	2.1 ± 0.1
83	β-Cedrene	1423	1421	1603	1606	tr
84	β-Copaene	1434	1432	1630	1631	0.1 ± 0.0
85	Aromadendrene	1442	1441	1609	1608	tr
86	*cis*-Muurola-3,5-diene*	1451	1450	-	1746	tr
87	*trans*-Muurola-3,5-diene*	1453	1454	1666	1663	tr
88	Geranyl acetone	1455	1455	1864	1865	tr
89	α-Humulene	1456	1455	1675	1670	0.5 ± 0.0
90	*allo*-Aromadendrene	1461	1460	1644	1646	tr
91	*cis*-Muurola-4(14),5-diene*	1465	1467	1673	1678	tr
92	γ-Gurjunene	1479	1477	1713	1714	tr
93	γ-Muurolene	1480	1480	1681	1684	0.2 ± 0.0
94	γ-Curcumene	1481	1483	1693	1690	0.2 ± 0.0
95	Germacrene D	1485	1485	1697	1693	0.1 ± 0.0
96	(*Z*,*E*)-α-Farnesene	1490	1491	1745	1747	0.1 ± 0.0
97	*trans*-Muurola-4(14),5-diene*	1493	1494	1707	1710	0.1 ± 0.0
98	Tridecan-2-one	1495	1496	1817	1814	0.1 ± 0.0

99	α-Muurolene	1501	1500	1731	1729	0.1 ± 0.0
100	β-Himachalene	1505	1505	1711	1713	tr
101	β-Bisabolene	1508	1506	1719	1715	0.1 ± 0.0
102	Shyobunone	1511	1510	1860	1859	tr
103	γ-Cadinene	1513	1514	1760	1760	0.1 ± 0.0
104	Cubebol	1517	1515	1928	1930	tr
105	δ-Cadinene	1520	1523	1764	1762	0.4 ± 0.0
106	*trans*-Calamenene	1531	1529	1841	1844	tr
107	(*Z*)-Nerolidol	1533	1533	2005	2008	tr
108	*trans*-Cadina-1(2),4-diene*	1536	1535	1775	1777	tr
109	α-Cadinene	1540	1539	1813	1815	tr
110	α-Calacorene	1548	1546	1914	1916	tr
111	Caryophyllene alcohol	1573	1572	2031	2033	tr
112	Germacrene D-4-ol	1577	1576	2041	2044	tr
113	Caryophyllene oxide	1585	1583	1986	1983	0.3 ± 0.0
114	Neryl 3-methylbutanoate	1586	1584	-	1884	tr
115	Humulene epoxide I	1591	1593	2046	2043	tr
116	Viridiflorol	1594	1593	2096	2099	tr
117	Humulene epoxide II	1604	1608	2077	2070	0.1 ± 0.0
118	1,10-di-*epi*-Cubenol	1615	1619	2051	2054	tr
119	1-*epi*-Cubenol	1630	1629	2074	2072	tr
120	Caryophylla-4(14),8(15)-dien-5-α-ol*	1639	1641	2316	2320	tr
121	(*Z*)-Methyl jasmonate	1641	1642	2402	2404	0.1 ± 0.0
122	*epi*-α-Muurolol	1643	1644	2197	2195	tr
123	α-Muurolol	1646	1646	2185	2182	tr
124	α-Cadinol	1650	1654	2223	2221	0.2 ± 0.0
125	(*E*)-Amyl cinnamic alcohol	1660	1661	-	-	tr
126	α-Bisabolol	1682	1686	2224	2228	tr
	Monoterpene hydrocarbons					45.8 ± 4.3
	Oxygenated monoterpenes					44.1 ± 4.1
	Sesquiterpene hydrocarbons					4.3 ± 0.3
	Oxygenated sesquiterpenes					0.6 ± 0.0
	Aliphatic compounds					2.5 ± 0.2
	Aromatic compounds					1.5 ± 0.1
	Others					0.2 ± 0.0

aRIA and RIP, experimental linear retention indices on DB-5ms and DB-Wax column, respectively. bRIAO and RIPO, linear retention indices from standard or literature on DB-5ms and DB-Wax column, respectively. cQuantitated in the nonpolar column, dtr (<0.1%). *Tentatively identified compound by comparison with literature data

Table No. 2
Antioxidant effectiveness of *Chuquiraga arcuata* essential oil

Sample	DPPH	ABTS	FRAP	
	IC_{50} (mg/mL)	IC_{50} (mg/mL)	Concentration (mg/mL)	(µM of ascorbic acid equivalents)
Essential oil	9.8 ± 0.24	34.5 ± 0.27	4	156.89 ± 0.01
			2	135.03 ± 0.01
			1	125.20 ± 0.01
			0.5	117.03 ± 0.01
Trolox	0.01 ± 0.01	0.025 ± 0.01	0.037	195.70 ± 8.40

Values are the mean of three determinations with standard deviation

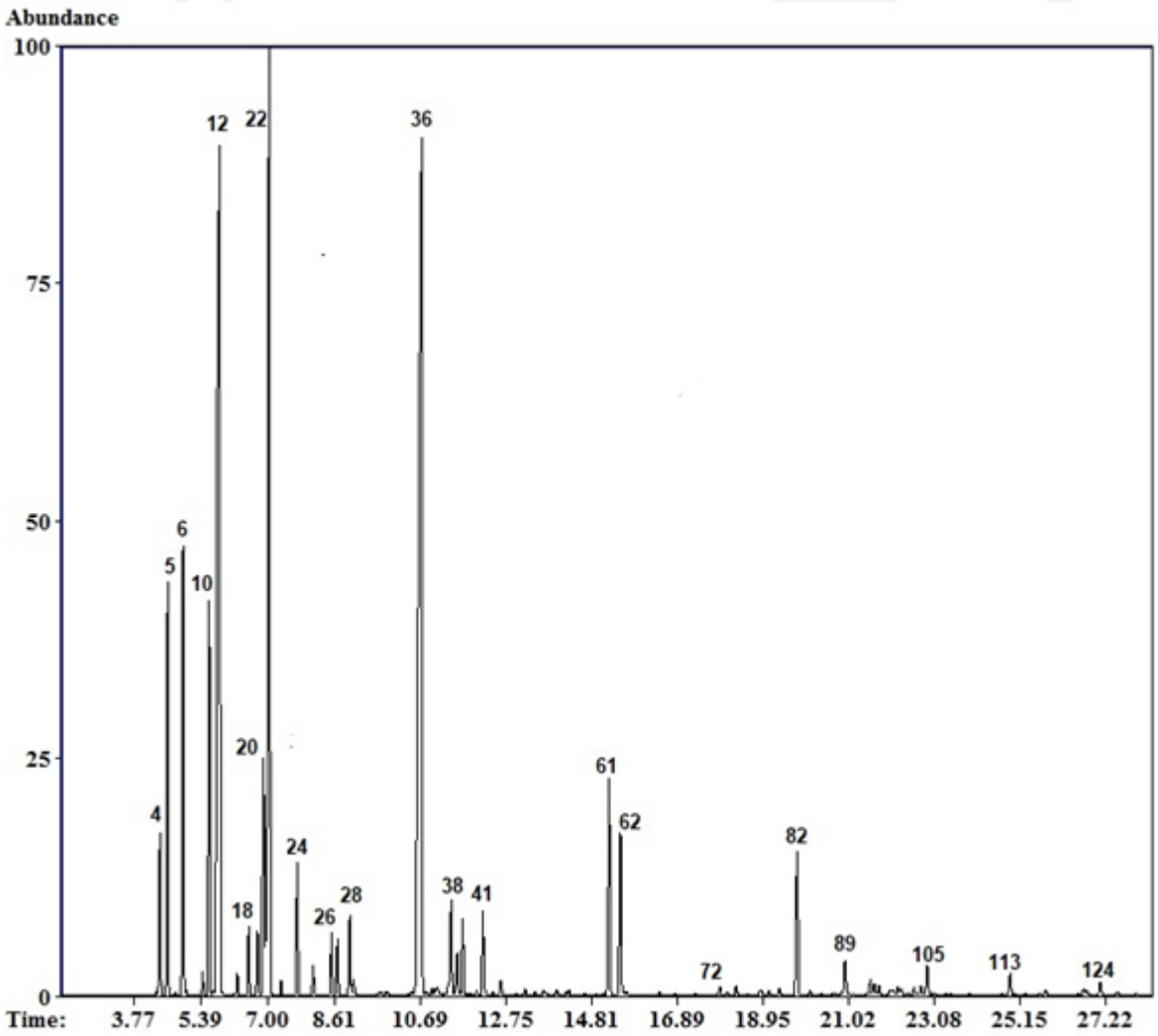

Figure No. 1
Chromatographic profile on DB-5ms column of the essential oil from *Chuquiraga arcuata* Harling

In summary, *Chuquiraga arcuata* essential oil from leaves and flowers showed moderate antioxidant properties. This capacity is generally due to the presence of phenolic compounds (Amorati *et al*., 2013), but the composition of *Chuquiraga arcuata* essential oil is poor in these compounds. Nevertheless, other compounds as phenylpropanoids, monoterpenes and oxygenated sesquiterpenes are compounds that show oxidation inhibition capacity (Shaaban *et al*., 2012). Although it is difficult to attribute the antioxidant activity to a single constituent in a complex mixture, this activity may be related to the dominance of myrcene and 1,8-cineole that have been categorized as significant antioxidants (Ciftci *et al*., 2011; Cai *et al*., 2021).

The antimicrobial activity of the *Chuquiraga arcuata* essential oil was evaluated against four pathogenic bacterial strains and a pathogenic fungus strain. The results in terms of net zone of inhibition and minimum inhibitory concentration are summarized in Table No. 3. The essential oil exhibited low (ZOI < 5 mm), moderate (ZOI = 5-9.9 mm), good (ZOI = 10-15 mm) or very good (ZOI > 15 mm) activities against studied microbial strains. The essential oil showed very good activity against *C. albica* and good against *S. aureus*. However, it showed moderate activities against *E. coli* and *P. aeruginosa*, and low activity against *S. enterica* serovar. The MIC value of the essential oil varied from 2.43 to 12.10 µL/mL, with the lowest for *E. coli*. The antimicrobial activity of the essential oils may be due to the occurrence of high proportion of oxygenated monoterpenes, which usually presents activity against microbial cells (Shaaban *et al*., 2012). Camphor exhibited no antibacterial and antifungal activity while it has significant activity together with

1,8-cineole, as indicated against *C. albicans* and *C. krusei* (Viljoen *et al*., 2003). Others major or minor constituents present in the essential oil might be responsible for the antimicrobial activity exhibited. Thus, probable synergistic or antagonistic properties of the compounds present must be taken into consideration (Lopes-Lutz *et al*., 2008).

Table No. 3
Antimicrobial activity of *Chuquiraga arcuata* essential oil

	ZOI (mm)	MIC (µL/mL)
Staphylococcus aureus	11.30 ± 0.57	3.12 ± 0.33
Ciprofloxacin	23.70 ± 0.21	0.19 ± 0.30
Escherichia coli	8.67 ± 0.57	2.43 ± 0.34
Ciprofloxacin	31.3 ± 0.32	0.12 ± 0.30
Salmonella enterica serovar	4.32 ± 0.14	12.10 ± 5.87
Ciprofloxacin	32.0 ± 0.56	0.39 ± 0.17
Pseudomonas aeruginosa	6.23 ± 2.73	8.23 ± 2.87
Ciprofloxacin	31.70 ± 0.36	0.27 ± 0.37
Candida albicans	15.56 ± 0.81	2.63 ± 0.18
Ketoconazole	31.30 ± 0.11	0.29 ± 0.01

ZOI: net zone of inhibition. MIC: minimum inhibitory concentration
Values are means ± standard deviation of three separate experiments

CONCLUSIONS

To the best of our knowledge, as far as the literature is concerned, the results presented in this work can be considered as the first report about the composition and biological properties of the essential oil from leaves and flowers of *Chuqiraga arcuata* Harling. One hundred and twenty-six compounds were identified in the essential oil. Monoterpene hydrocarbons (45.8%) and oxygenated monoterpenes (44.1%) have the major percentage. The most abundant compounds were camphor (21.6%), myrcene (19.5%), and 1,8-cineole (13.4%). The essential oil exerted a moderate scavenging effect and reduction of ferric ion capacity through FRAP assay. With the exception of S. enterica serovar, the essential oil exhibited activity against most of the microorganism strains tested, particularly against *Candida albicans* and *Staphylococcus aureus*.

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